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FLEXIBLE, WATER-RESISTANT URETHANE COATINGS FOR FERROUS SURFACE--ETC(U)
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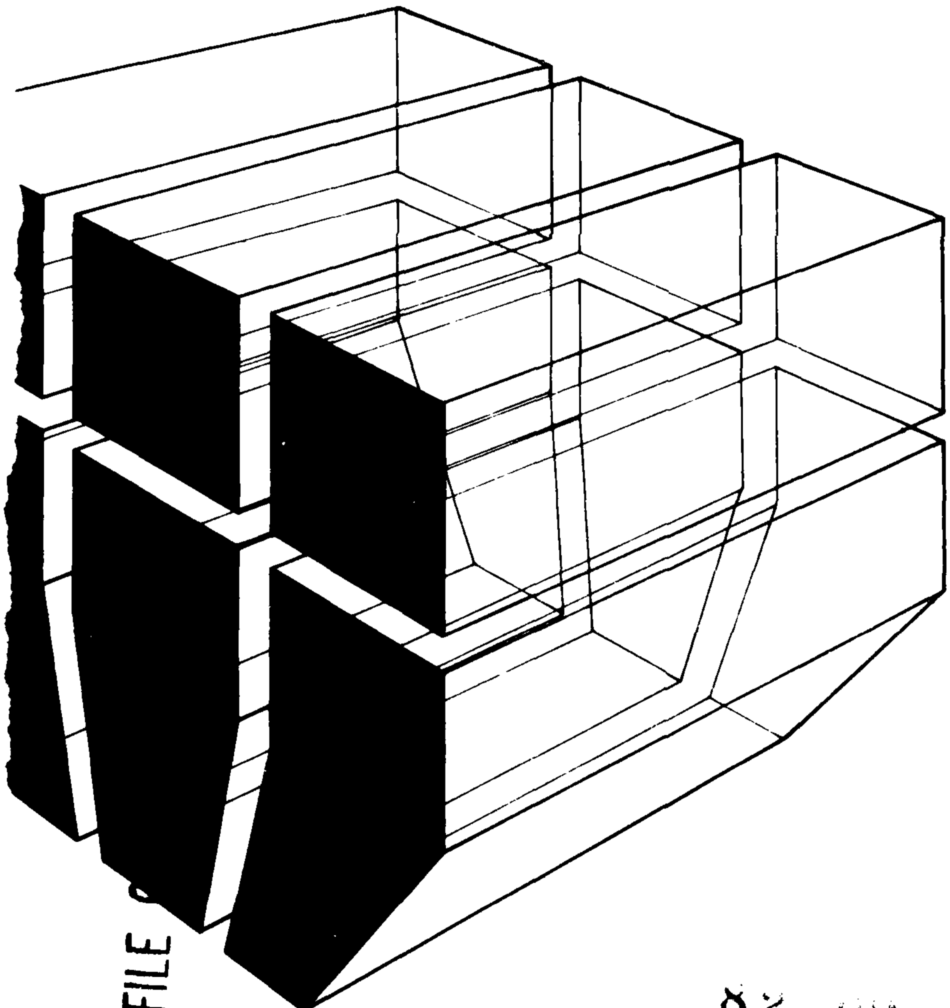
Technical Report M-319
July 1982

FLEXIBLE, WATER-RESISTANT URETHANE COATINGS FOR FERROUS SURFACES ON U.S. ARMY CORPS OF ENGINEERS' DAMS



by
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The overall purpose of this study is to evaluate formulations for an extremely tough, water-resistant, urethane base coating which will withstand the punishment and erosion of turbulent waters carrying sand, ice, and other debris. The objective of the short-term phase of the study documented in this report was to assess ambient-air-curing elastomeric coatings to identify those with high tensile strength and elongation properties and excellent water resistance.

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More than 200 coatings were prepared, based on the most promising prepolymers, polyols, and diisocyanates. Films of the coatings showing the highest tensile strength were subjected to a hydrolytic stability test, the result of which indicated losses in tensile strength of up to 50 percent. Series of coatings were formulated and prepared based on polyester polyols and polyether polyols, and the resulting coatings were subjected to the hydrolytic test after curing for 2 weeks at ambient temperature. The result indicated that the test cycle was too short for conclusive determination of hydrolytic stability.

The data in this study was obtained from ambient-temperature-curing urethane elastomeric coatings containing solvents. Coatings based on polyester polyols have a maximum tensile strength of up to 2800 psi; for those based on polyethers, the maximum tensile strength was 1800 psi. The associated elongation was 700 to 800 percent. From the tacky condition of the hydrolytic stability tested films, one may conclude that polyester-based polyols may develop reversion problems. The hydrolytic stability tests indicate that the Y series films—combinations of polyesters for strength and hardness and polyethers for hydrolytic stability—are not better than the X series.

The highest possible tensile strength and elongation, as shown by the Y6 formula (Table 18), was obtained by using the high-molecular-weight Niax PCP 0240 polyester polyol in the prepolymer. It must be further determined whether high molecular weight polyols produce water-sensitive urethanes.

FOREWORD

This research was done for the Directorate of Civil Works, Office of the Chief of Engineers (OCE), under project CWIS 31205, "Development of High Performance Coatings." Mr. J. Robertson was the OCE Technical Monitor.

The work was conducted for the Engineering and Materials Division (EM) of the U.S. Army Construction Engineering Research Laboratory (CERL) by Plas-Chem Coatings Laboratory, St. Louis, MO. Dr. R. Quattrone is Chief of EM.

COL Louis J. Circeo is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

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TABLES

FLEXIBLE, WATER-RESISTANT URETHANE COATINGS FOR FERROUS SURFACES ON U.S. ARMY CORPS OF ENGINEERS' DAMS

1 INTRODUCTION

Background

Vinyl solution coatings have been used to protect U.S. Army Corps of Engineers hydraulic structures from corrosion. The life expectancy of these coatings has been between 15 and 30 years, depending on the severity of exposure. In some regions, coatings on newly designed dams have life spans of less than 4 years because of the effects of water laden with turbulent silt, sand, ice, and other debris. The U.S. Army Construction Engineering Research Laboratory's (CERL) past field work has shown that hard coatings, both urethanes and epoxies, cannot withstand such abrasion. Therefore, the Office of the Chief of Engineers asked CERL to develop an extremely tough, water-resistant coating that would withstand the environment and protect steel structures from corrosion.

Objective

The overall objective of this study is to evaluate urethane coatings for use on Corps dams. The purpose of the short-term phase of the study reported here was to assess formulations of ambient-air-curing elastomeric urethane coatings to identify those with high tensile strength and elongation properties and excellent water resistance.

Approach

To accomplish this objective, the following steps were taken:

1. Suppliers of prepolymers were invited to submit commercially available samples for testing; in addition, a number of special formulations were developed.

2. Samples of coatings were prepared and tested for tensile strength and elongation, hydrolytic stability, and 90-degree peel strength.

Mode of Technology Transfer

Information about more durable coating systems will be incorporated into Guide Specification CW-09940 and, where appropriate, described in EM-1110-2-3400, *Painting: New Construction and Maintenance.*

2 MATERIALS

Requirements

To be usable by the Corps, the coating formulation being developed had to meet several requirements. It had to be manufactured from readily available raw materials and had to be producible by any paint company able to manufacture urethane paints. The coating also had to be applicable at various ambient temperatures by a conventional or single-component airless spray handled by applicators with average professional skills. In addition, test requirements shown in Table 1 had to be met. Urethane coatings with these characteristics are made from four basic components: prepolymer, chain extender, catalyst, and pigments and flow additives.

Commercial Products

Initially, all known U.S. suppliers of prepolymers were invited to recommend prepolymer/chain extender systems which would produce a coating with the specified characteristics. Five suppliers responded. One submitted a pigmented commercial product which did not fit the specification, two submitted samples of "best bet" prepolymers without recommending a chain extender, one submitted a sample chain extender, and one asked about the potential usage but did not have any recommendations.

Most prepolymer manufacturers specify tensile strength; elongation values are obtained if prepolymers are processed into elastomers using MOCA (4.4'-methylene-bis 2-chloroanaline) as the chain extender. Elastomers of lower hardness can be obtained with other polyols. Manufacturers sometimes say that elastomers cured at ambient temperatures with proper catalysts will yield similar properties in 1 to 3 weeks.[1]

Materials Selection

A few commercially available prepolymer samples were ordered. In addition, a number of prepolymers were prepared from the most promising polyols and diisocyanates to determine how strong an ambient-temperature-curing elastomeric coating could be made. It was assumed that the formulated prepolymers, if more successful than commercial products,

[1] Anderson Development Company data sheet covering prepolymer: Andur 80-5AP; Conap data sheet covering DP 2816 A & B; Uniroyal Chemical data sheet covering Vibrathane B604.

Table 1
Test Requirements

Total % solids by wt, minimum (ASTM D-1353)*	40%
Potlife @ 75°F	1 hr
Potlife @ 100°F	45 min
Mixing ratio	1:1
Low temperature cure	50°F
Film build in two double spray coats	20 mils
Tear strength (ASTM D 1004)	1.00 lb/mil
Elongation (ASTM D 2370)	400%
Tensile strength (ASTM D 2370)	4000 psi
Peel strength (applied over V766e, 90 degree peel)	25 lb/in. (minimum)
Color (gray) reflectance (ASTM E 97)	20 to 24
Water resistance (immersion for 1 week in 120°F distilled water)	No blistering or noticeable film degradation; meets peel strength
Storage stability	1 year in factory-sealed container

**Test for Nonvolatile Matter in Volatile Solvents for Use in Paint, Varnish, Lacquer, and Related Products,* American Society for Testing and Materials (ASTM) D 1353 (1978); *Test for Initial Tear Resistance of Plastic Film and Sheeting,* ASTM D 1004-66 (1976); *Test for Elongation and Tensile Strength of Free Films of Paint, Varnish, Lacquer, and Related Products with a Tensile Testing Apparatus,* ASTM D 2370-68 (1973); *Test for 45-deg, 0-deg Directional Reflectance Factor of Opaque Specimens by Broad-Band Filter Reflectometry,* ASTM E 97 (1977).

could be produced on a specialty basis by interested manufacturers.

In general, the polyols selected contained all primary hydroxyl groups that cure best—i.e., the polytetramethylene ether glycols (PTMEG) and the Niax (PCP) Caprolcatone ester diols and triols; these produce the most hydrolytically stable urethanes.

The isocyanates used in this study were the toluene diisocyanate 80/20 (TD 80), diphenylmethane diisocyanate (MDI) and methylene bis (4 cyclohexyl isocyanate) (HMDI), also known as hydrogenated MDI.

MOCA, which adds toughness to urethanes, was another polyol considered, but it was not used because it is a suspected carcinogen and produces a surface that is difficult to overcoat. Hydroxyl-terminated polybutadiene was considered because of its inherent hydrolytic stability. However, it was not used because it contains unsaturated sites susceptible to attack by oxygen and ozone, which causes the cracking and crazing common with this type of urethane.

Since no triol PTMEG polyether polyols are commercially available, and only two of the PCP triols are fluid at application temperature, the formulation of a coating mixable in a 1:1 ratio was severely limited. But because the crystalline nature of other polyols could be reduced by preparing them as hydroxyl-terminated prepolymers, greater flexibility could be achieved.

3 TEST SPECIMEN PREPARATION

Eight steps were taken to prepare over 200 coating specimens which were being tested:

1. Preparing an OH-terminated polyol or prepolymer, or selecting a commercial one. Polyols were selected on the basis of being fluid at 50°F or above and having a suitable primary hydroxyl content. Only the Niax PCP 0300 polyol could be used as is. A number of OH-terminated prepolymers were prepared as follows. The polyol and 50 percent of a solvent were charged in a 1-L glass reactor equipped with a stirring mechanism, dry nitrogen inlet, heating mantle, additional funnel, and thermometer. Isocyanate and the remaining solvent were stirred in slowly, and the temperature was kept below 176°F. Then the prepolymer was reacted for 3 hours, cooled down, and canned. The ratio of OH to NCO was usually 2:1.

2. Using a high-speed disperser to add suitable amounts of pigment, extender pigment, solvent, thixotrope, and curing catalyst to the polyol or polymer. The mixture was dispersed until the temperature reached 131°F and a grind check was satisfactory.

3. Preparing an NCO-terminated prepolymer or selecting a commercial one. The NCO-terminated prepolymers were prepared by charging into the high-speed disperser the appropriate amount of isocyanate

and half the solvent and adding melted polyols at approximately 140°F. Then the temperature was raised to 176°F for 3 hours. The prepolymers were prepared in an NCO-to-OH ratio of 2:1. The final free NCO content was then determined by the standard butylamine method. In the few cases when a catalyst was present during the reaction, a maximum temperature of 140°F was used.

4. Determining the mixing weight ratio of the OH-terminated polyol or prepolymer and NCO-terminated prepolymer by establishing their individual equivalent weights. The equivalent weight factor was calculated on the basis of the total weight, and the amount and equivalent weight of the polyol or polymer.

5. Combining the OH-terminated polyol or prepolymer and NCO-terminated polymer, generally with a 10 percent excess of the NCO component.

6. Using a film applicator to prepare a film about 15 mils thick on silicon-treated release paper.

7. Letting the film cure at ambient temperature for 2 days.

8. Peeling the film off the paper and hanging it up for conditioning for 2 days to permit further curing and release of most retained solvents.

The test specimens were produced from the cured films by cutting the required shapes for tensile strength and elongation testing using Die A and C in accordance with ASTM D 412, and the die specified in ASTM D 1004 for tear strength determination.[2] The testing machine was the Dillon model M 1 Tensile Strength Tester with a speed of separation of 50 mm/min.

4 RESULTS AND ANALYSIS

Tables 2 through 18 show the coating formulas and the test results. Most T2-18 data, particularly for tensile strength (TS) and elongation (EL), are stated below the formulas listed on the tables. If a coating showed TS and EL values approximating those specified in the test requirements (Table 1), hydrolytic stability and peel strength were tested.

Tensile Strength and Elongation

As the tables indicate, only a few coatings developed TS values above 2000 psi. All TS values were taken after 72 hours of curing, unless otherwise noted. It was difficult to mix the pigmented base and prepolymer together without getting air into the mixture. Films from spray application were no better than those produced by a film applicator and the standard draw down method—with and without a subsequent exposure to a vacuum treatment while wet. Although air bubbles prevented the calculation of absolute TS and EL values, the error was minor and almost equal for all the coatings. (Combining the components under vacuum might produce an airless mixture, but application would still introduce air into the films.)

Most urethane literature by suppliers of the basic raw materials offers examples of urethane compositions and shows 5500 psi for TS and 400 to 500 percent for EL.[3] These data are obtained by casting the urethane composition in hot molds under vacuum. The molds are usually cured for 16 hours at 230°F. A post-cure for 5 to 7 days at room temperature is necessary for the urethane elastomer to achieve optimum physical properties.

Air-curing the same composition at room temperature does not produce elastomers with near-identical properties[4] because any retained solvent will tend to act as a plasticizer. In addition, during curing the film will be exposed to water vapors, which will interfere with the formation of urethane groups in two ways: the water will react with the free NCO groups and form ureas and biurets, and unreacted polyol will be left in the film.

Hydrolytic Testing

The eight coatings with high tensile strengths were subjected to a hydrolytic test, as described in Table 16. The retained tensile strength according to this test was about 21 to 47 percent, indicating major problems.

The highest tensile strengths after hydrolytic testing were obtained by mixtures of polyester and polyether polyols, generally considered the polyols producing urethane with the highest hydrolytic stability. Another test was started with one series of coatings based on all polyesters and another based on all polyethers. The

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[2] *Tests for Rubber Properties in Tension*, ASTM D 412 (1980).

[3] The Quaker Oats Company, *Polyurethane Elastomers Based on MDI-Polymeg Prepolymers Extended with 1, 4 Butane Diol.*, Technical Bulletin No. 169.

[4] E. N. Doyle, *The Development and Use of Polyurethane Products* (McGraw-Hill, 1971), p 48.

films were cured for 14 days before hydrolytic testing. Tables 17 and 18 show the compositional and physical data obtained.

When the films in the Y series—all polyester based—were removed from the hot water, they were soft and tacky (Table 18). A permanent bond was formed if they touched each other. However, when they dried, their physical properties had not changed as much as expected.

The films in the X series, all polyether based, were far less affected by the hot water, were not tacky, and when dry, tended to show increases in tensile strength. This seems to indicate that the slower curing polyether had not reached final cure at the time of immersion, and that further curing took place during immersion.

The films in the X and Y series were tested after curing for 2 weeks at ambient temperature. The results described above indicate that the test cycle was too short to conclusively determine hydrolytic stability—longer curing times and periods of water immersion would be appropriate. (Of course, field-applied coatings are exposed to the elements almost immediately.)

A recent National Aeronautics and Space Administration (NASA) study deals with the long-term hydrolytic stability of urethane elastomers used with electronic equipment.[5] The results of this research, which emphasizes the performance of alkane-based urethanes, deserve further study. Although the relationship of any hydrolytic stability test with actual field performance is unknown, Morris is probably right when he says, "If the urethanes absorb water, the urethane bond will be more susceptible to cleavage. If the polymer bond is broken, the resin would become soft and tacky. (Thus hardness change can be used as an indication of hydrolytic attack.)"[6] Plas-Chem Coatings Laboratory's experience with all-polyester-based urethane coatings exposed for years to almost continuous water immersion on roofs in the Miami area indicates that the coatings normally lose some elasticity with time, and thus become harder. However, this applies only to low molecular polyesters necessary for high solids coatings. The NASA study may be correct in associating the poorest hydrolytic stability with the higher molecular weight polyols.

Some two-component urethane coatings have not been explored fully. The 100 percent solids, fast-curing urethanes, which can be applied by plural component airless spray, are now becoming increasingly popular with paint applicators. With these coatings, the length of time the NCO is available for combining with moisture is cut drastically, and unwanted urea and biurets groups are formed far less. A more hydrolytically stable product might result.

Peel Strength

Urethanes should adhere to the Corps of Engineers' standard V-766 coating formula. To test this characteristic, panels coated with V-766 were taped with strip of 3/4-in.-wide masking tape, and 50-mil urethane coatings were applied. The panels were scribed along the edges and beyond the length of the tape, and pulled using a spring scale. An untreated panel and one immersed for 1 week in water at 140°F passed the 25-lb pull test. A solvent combination of cellosolve acetate and xylol, a marginal solvent blend for vinyl coating, helped adhesion.

5 CONCLUSIONS AND RECOMMENDATIONS

The data obtained in this study indicate that ambient-temperature-curing urethane elastomeric coatings based on polyester polyols containing solvents have a tensile strength of up to 2800 psi; for those based on polyethers, the maximum tensile strength is 1800 psi. The associated elongation for both the polyesters and polyethers is 700 to 800 percent. From the tacky condition of the films tested for hydrolytic stability, it can be concluded that polyester-based polyols may develop reversion problems. The hydrolytic stability tests indicate that the Y series films—combinations of polyesters for strength and hardness and polyethers for hydrolytic stability—are not better than the polyether-based X series.

The highest possible tensile strength and elongation, as shown by the Y6 formula (Table 18), was obtained by using the high-molecular-weight Niax PCP 0240 polyester polyol in the prepolymer. However, because the hydrolytic stability test was done too quickly, it must still be determined whether high-molecular-weight polyols produce water-sensitive urethanes.

[5] Donald E. Morris, *Development of Urethane Coatings and Potting Material With Improved Hydrolytic and Oxidative Stability*, TM 82408, N-81-22192/1 (National Aeronautics and Space Administration, 1981), p 20.

[6] Donald E. Morris, p. 20.

Since this was a short-term study, further research on the X and Y series, the most advanced formulations, *is needed to evaluate the durability of these coatings over time.* Two polyether-based coatings from Table 17 should undergo more lengthy laboratory testing before being field tested: coating X9 is a low molecular polyol version, and X10 is a medium molecular polyol version with better tensile strength and elongation properties. If the conclusions of the NASA study are true, X9 should perform better than X10; a coating like X11, containing high-molecular-weight polyol, should deteriorate even sooner. From Table 18, the Y1 coating, a relatively low-molecular-weight species, and Y4, a high-molecular-weight candidate, should be evaluated further.

It is also recommended that hybrid coatings be examined. For example, a hybrid such as a vinyl or butadiene modified urethane might eliminate the need to shield the urethane groups from exposure to water. Use of high-solids, fast-curing urethanes requiring plural component spray equipment might be another way to prevent moisture contamination and hydrolytic stability problems.

Table 2
Prepolymers, Commercial

1.1:*	**Recommended by Manufacturer**	**2****	**3**
	Vibrathane #635†	605	
	Vibrathane #625		698
	Xylol	120	80
	Toluol	120	80
	Total	845	858
	Equivalent Weight (Eq. Wt.)	845	858
	Appearance	Clear	Clear
1.2:	**Selected by CERL**	**1**	**2**
	Andur 80-5 AP	540	
	Andur 850-AP		540
	Cellosolve Acetate	180	180
	Xylol	180	180
	Total	900	900
	Free NCO, %††	2.07	2.58
	Eq. Wt.	2029	1628
	Appearance	Clear	Clear

*Decimal notations are reference numbers assigned to coating formulas in Tables 2 through 18.
**Formulation numbers assigned by CERL; units for formulations are ingredients in parts, by weight.
†See the appendix for a list of trade names and manufacturers.
††A list of abbreviations is provided on p 30.

Table 3
Prepolymers, Prepared, TDI/Polyether

1.3	1	2	3	4	5	6	7	8
TD 80	272	161	185.3	218.9	90	318.8	142.2	335.5
Teracol 650	478							573
Poly Meg 1000		439	405.5	359.4		220.2		
Teracol 2000					510		444	
TMP			9.2	21.7			14.2	
1.4 Butane Diol						62		
Cellosolve Acetate			200	200	200	200	200	
Xylol	250	400	200	200	200	200	200	91.5
Total	1000	1000	1000	1000	1000	1001	1001.4	1000
Solids, %	75	60	60	60	60	60	60	90.8
Free NCO	6.84	4.06	4.66	5.50	2.26	7.97	3.56	8.85
Eq. Wt.	614	1034	901	764	1858	527	1171	473.5
Appearance	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear

Table 4
Prepolymers, Prepared, MDI/Polyether

1.4	1	2	3
Mondur M (Mobay Chemical)	318	253	170
Teracol 650	282		
Polymeg 1000		347	
Teracol 2000			430
Cellosolve Acetate	200	200	200
Xylol	200	200	200
Total	1000	1000	1000
Solids, %	60	60	60
Free NCO	7.08	5.64	3.31
Eq. Wt.	593	740	1250
Appearance	Clear	Clear	Clear

Table 6
Prepolymers, Prepared, MDI/Polyester

1.6	1
TD 80	59
Mondur M	43
Niax PCP 0260	498
Cellosolve Acetate	200
Xylol	200
Total	1000
Solids, %	60
Free NCO	2.85
Eq. Wt.	1473
Appearance	Clear

Table 5
Prepolymers, Prepared, TDI/Polyester

1.5	1	2	3	4
TD 80	114.5	162	91	310
Formrez E65-73	485.5			
Formrez L4-55		438		
Niax PCP 0240			509	
Niax PCP 0210				662
Cellosolve Acetate	200	200	200	
Xylol	200	200	200	28
Total	1000	1000	1000	1000
Solids, %	60	60	60	97.2
Free NCO	2.88	4.06	2.20	8.16
Eq. Wt.	1458	1034	1898	514.5
Appearance	Clear	Clear	Clear	Clear

Table 7
Prepolymers, Prepared, HMDI/Polyester

1.7	1	2
Desmodur W	68	84
TD 80	46	57
Niax PCP 0240	486	432
Niax PCP 0230		20
TMP		7
DBTDL, 10%	5	
Cellosolve Acetate	200	200
Xylol	195	200
Total	1000	1000
Solids, %	60	60
Free NCO	2.31	2.79
Eq. Wt.	1821	1504
Appearance	Clear	Clear

Table 8
Prepolymers, Prepared, MDI/TDI/Polyester/Ethers

1.8	1	2	3	4
TD 80	44	49	48	43
Mondur M	124	70	69	124
Teracol 2000	432	481	238	213
Niax PCP 0240			245	220
Cellosolve Acetate	200	200	200	200
Xylol	200	200	200	200
Total	1000	1000	1000	1000
Solids, %	60	60	60	60
Free NCO	4.35	2.60	2.52	4.33
Eq. Wt.	958	1618	1666	963
Appearance	Seedy	Clear	Clear	Clear

Table 9
Prepolymers, Prepared, HMDI/Polyester/Ethers

1.9	1	2	3	4	5
Desmodur W	276	217	135	136	191
Teracol 650	324				
Polymeg 1000		387			
Teracol 2000			465		
Niax PCP 0240				464	
Niax PCP 0230					409
Cellosolve Acetate	200	200	200	200	200
Xylol	200	200	200	190	190
DBTDL, 10%				10	10
Totals	1000	1004	1000	1000	1000
Solids, %	60	60	60	60	60
Free NCO	4.60	3.63	2.27	2.37	3.33
Eq. Wt.	913	1157	1852	1773	1261
Appearance	Clear	Clear	Clear	Clear	Clear

1.9	6	7	8	9	10	11
Desmodur W	227	183	198	223	100	229
Teracol 650	131	106	57.2	85		
Niax PCP 0240		311	337	255		571
Niax PCP 0230	242					
TMP			7.8			
Olin TP440				37		
Niax PCP 0260					500	
DBTDL, 10%	10	10	10	10	5	
Cellosolve Acetate	200	200	200	200	200	100
Xylol	190	190	190	190	195	100
Totals	1000	1000	1000	1000	1000	1000
Solids, %	60	60	60	60	60	80
Free NCO	3.96	3.19	3.45	3.87	1.73	4.88
Eq. Wt.	1060	1317	1218	1085	2433	860
Appearance	Seedy	Clear	Clear	Clear	Clear	Clear

Table 10
Polyol Bases, Pigmented, Polyester

2.3	1A	1B	1C	2A	2B	3B	3A
Niax PCP 0300	359			90		54	831
Niax PCP 0301		364					
Niax PCP 0310			363				
Polymeg 1000				258		361	
Doyle #2B PP					583.5		
Cellosolve Acetate				100			110
Xylol	145	145	145	100		150	
Thixatrol ST	15	15	15	15	15	15	15
Titanium Dioxide	400	400	400	300	300	300	300
Talc 30-36	200	200	200				200
Novacite 1250	250	250	250	250	250	250	
DBTDL, 10%	2	2	2		1		
U/L 28				1			1
SC100		58	58	58			
Total	1429	1434	1433	1114	1149.5	1130	957
Yield, Gal	102	102	102				70
Lb/Gal	14.0	14.06	14.05				13.75
Eq. Wt.	721.7	395	1184	1114	1149	1130	525

Table 11
Hydroxyl-Terminated Prepolymers

	Polyether							
2.5	0	1	2	4	5	6	7	10
TD 80	68	48	24	115	164	114	83	48
Polymeg 650	532			423	304	281		
Polymeg 1000		552					472	
Teracol 2000			576					526
1.4 Butane Diol				62	132	205	45	26
Cellosolve Acetate	200	200	200	200	200	200	200	200
Xylol	200	200	200	200	200	200	200	200
Total	1000	1000	1000	1000	1000	1000	1000	1000
Solids, %	60	60	60	60	60	60	60	60
Ratio, TDI: PTMEG-Modifier	1:2	1:2	1:2	1:1:1	2:1:3	3:2:10	1:1:1	1:1:1
Lb/Gal	8.02	8.09	8.13	8.45	8.55	8.43	8.20	8.18
Eq. Wt.	1277	1811	3584	757	530	232	1032	1792
Viscosity, centipoise (CPS)	240	200	47	280	260	96	170	152
Freeze/Thaw	OK	OK	OK	OK	OK	OK	OK	OK
Appearance	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Hazy gel

Table 11 (Cont'd)

2.5	Pigmented Bases 0A	1A	2A	4A	5A	6A	7A	10A
PP 2.5-0	552							
2.5-1		552						
2.5-2			552					
2.5-4				552				
2.5-5					552			
2.5-6						552		
2.5-7							552	
2.5-10								552
Thixatrol ST	15	15	15	15	15	15	15	15
Titanium Dioxide	400	400	400	400	400	400	400	400
Talc 30-36	200	200	200	200	200	200	200	200
Novacite 1250	250	250	250	250	250	250	250	250
DBTDL	1	1	2	2	1	2	1	2
Total	1418	1418	1418	1418	1418	1418	1418	1419
Lb/Gal	13.85	13.91	13.76	13.61	13.78	14.00	13.90	13.85
Viscosity	52,000	4200	50,500	54,000	53,000	Paste	Paste	Paste
Eq. Wt.	3280	4645	9206	1944	1361	611	2652	4607

2.5	Polyether 13	14	15
TD 80	112.3	83	
Mondur M			149
Teracol 650	429.2		397
Polymeg	1000	473	
TMP	58.5	44	44
Cellosolve Acetate	200	200	200
Xylol	200	200	200
Total	1000	1000	1000
Solids, %	60	60	60
Ratio, TDT-MDI: PTMEG:Modifier	1:1:1	1:1:1	1:1:1
Lb/Gal	8.40	8.35	8.40
Eq. Wt.	775	1022	839
Viscosity, CPS	262	270	270
Freeze/Thaw	OK	OK	OK
Appearance	Clear	Clear	Clear

2.5A	Pigmented Bases 13A	13B	14A	15A
PP 2.5-13	552	552		
2.5-14			552	
2.5-15				552
Thixatrol ST	15	15	15	15
Titanium Dioxide	300	300	300	300
Talc 30-36	100	200	100	100
Novacite 1250	250	----	250	250
DBTDL-UL28	1	1	1	1
Total	1218	1068	1218	1218
Lb/Gal	12.15	12.23	12.13	12.16
Viscosity	Pasty	Pasty	Pasty	Pasty
Eq. Wt.	1710	1500	2256	1851

Table 12
Hydroxyl-Terminated Prepolymers, Polyester Based

	Polyester	
2.6	**1**	**2**
TD 80	39	95
Niax PCP 0230	561	
Niax PCP 0210		455
TMP		50
Cellosolve Acetate	200	200
Xylol	200	200
Total	1000	1000
Solids, %	60	60
Ratio, TDI:ESTER:Modifier	1:2:5	1:1:1
Lb/Gal	8.52	8.62
Viscosity, CPS	310	350
Freeze/Thaw	OK	OK
Appearance	Clear	Clear

	Pigmented Bases	
2.6A	**1A**	**2A**
PP 2.6-1	552	
2.6-2		552
Thixatrol ST	15	15
Titanium Dioxide	400	300
Talc 30-36	200	200
Novacite 1250	250	
DBTDL	1	
UL28		1
Total	1418	1068
Lb/Gal	1410	1283
Viscosity	Pasty	Pasty
Eq. Wt.	5936	1742

Table 13
Hydroxyl-Terminated Prepolymers, Miscellaneous

2.7	1	2	3	4	5	9
TD 80					69	94
PP 1.4-3	530		665			
1.9-3		625				
1.3-5				605		
Teracol 650	285	225	177	237		238
Polymeg 1000					388	
Niax PCP 0230						220
Niax PCP 0300					143	
TMP			24			48
Cellosolve Acetate	94	75	67	79	200	200
Xylol	94	75	67	79	200	200
Total	1003	1000	1000	1000	1000	1000
Solids, %	60	60	60	60	60	60
Lb/Gal	8.20	8.22	8.12	8.14	8.20	8.21
Eq. Wt.	2358	2950	1890	2785	1273	945
Viscosity, CPS	277	310	250	320	260	230
Freeze/Thaw	OK	OK	OK	OK	OK	OK
Appearance	Clear	Clear	Clear	Clear	Clear	Clear

2.7	10	11	14
TD 80			68
Desmodur W	94	96	
Teracol 650	120	122	170
Niax PCP 0230			
Niax PCP 0240	353	359	253
TMP	33		
Glycerol		23	
TP 400			109
Cellosolve Acetate	200	200	200
Xylol	195	195	190
DBTDL, 10%	5	5	10
Total	1000	1000	1000
Solids, %	60	60	60
Lb/Gal	8.18	8.23	8.32
Eq. Wt.	1366	1328	1309
Viscosity, CPS	320	450	410
Freeze/Thaw	OK	OK	OK
Appearance	Clear	Clear	Clear

Table 14
Hydroxyl-Terminated Prepolymers, Miscellaneous, Pigmented Bases

2.7A	1A	1AA	2A	3A	4A	4B	4C	5A
PP 2.7-1	552	552						
PP 2.7-2			552					
PP 2.7-3				450				
PP 2.7-4					450			
Quadrol						2	6	
PP 2.7-4A						200	200	
PP 2.7-5								552
Thixatrol ST	15	15	15	15	15			15
Titanium Dioxide	300	300	300	300	300			300
Talc 30-36	100	100	100	100	100			100
Novacite 1250	250	250	250	250				250
DBTDL	1	3	1	1	1			
UL 28								1
Cellosolve Acetate	33	33	22	75	50			
Xylol	33	33	22	75	50			
Total	1284	1286	1262	1265	1215	202	206	1218
Lb/Gal	12.15	12.16	12.18	12.10	12.18	12.18	12.18	12.17
Viscosity	Pasty	Pasty	Pasty	Pasty	Pasty	Pasty	Pasty	Pasty
Eq. Wt.	5482	5482	6743	5313	7500	3733	1892	2808

2.7A	7A	8A	9A	10A	11A	14A
Vroh. Vinyl	150	150				
Polacure 740M	30					
PP 2.7-9		600				
PP 2.7-10				600		
PP 2.7-11					600	
PP 2.7-14						600
Thixatrol ST	15	15	15	15	15	15
Titanium Dioxide	300	300	300	300	300	300
Talc 30-36	100	100				
Novacite 1250	250	250	250	250	250	250
UL 28	1	1	1	1	1	1
Cellosolve Acetate	300	300				
Xylol	30	45	45	45	45	45
Total	1176	1146	1211	1211	1211	1211
Lb/Gal	13.1	13.0	11.85	11.90	11.87	11.92
Viscosity	Pasty	Pasty	Pasty	Pasty	Pasty	Pasty
Eq. Wt.	3200	6492	1994	2759	2679	2643

Table 15
Coatings

3.0		1	2	3	4	5	6	7	8
Polyol Base	2.3-1A	39.0			46.0				
(PB)	2.3-1B		26.0			32.0			
	2.3-1C			51.0			58.5		
	2.3-4A							48.8	
	2.3-5A								54.5
Prepolymer	1.3-2	61.0	74.0	49.0				51.2	45.5
(PP)	1.3-4				54.0	68.0	41.5		
	1.3-5								
Total		100	100	100	100	100	100	100	100
Film Appearance		E, G, S	I	E, G	E, G, S	I	E, G, S	IC	IC
Tensile Strength				843					
Elongation (EL)				200					

3.0	9	10	11	12	13	14	15	16
PB 2.5-5A		41.0			54.5			
2.5-6A	47.5	18.4	25.6	26.9		21.1	6.0	51.3
2.5-2A			42.9			35.3		
2.5-1A				36.0			48.4	
PP 1.3-2					45.5	43.6		
1.3-5							45.6	
1.3-1	52.5	40.6	31.5	37.1				
1.3-6								48.7
DBTDL, 90% Xylol					0.1			
Total	100	100	100	100	100.1	100	100	100
Film Appearance	E	E	ES	ES	IC	IC	IC	E
TS	1082	878	1368	1700		421		780
EL	640	700	680	540		260		300

3.0	17	18	19	20	21	22	23	24
PB 2.5-4A					45.9		30.2	
2.5-5A	70.0			61.8			21.1	
2.5-6A		27.0	37.7		14.4	24.6	9.5	10.0
2.5-2A		45.0						
2.5-1A			22.5			33.1		
2.5-7A								43.1
PP 1.3-4				38.2	39.7	42.3	39.2	13.7
1.3-6	30.0	28.0	39.8					
1.3-5								33.2
Total	100	100	100	100	100	100	100	100
Film Appearance	ES	IC, F	ES	E	E	E	E	ES, T
TS 266		687	867	657	933	833		
EL 720		440	640	480	560	520		

Table 15 (Cont'd)

3.0	25	26	27	28	29	29a	30	30a
PB 2.5-1A			48.4					
2.5-4A		31.4			44.5	44.5		
2.5-5A		22.0			13.4	13.4		
2.5-6A			9.0	12.4			10.5	10.5
2.5-7A	64.8			53.6			45.5	45.5
PP 1.3-4	10.2	13.6	12.4	34.0				
1.3-5	25.0	33.0	30.2					
1.3-7					42.1	42.1	44.1	44.1
Zirconium oct. 1.2%						0.2		0.2
Total	100	100	100	100	100	100.2	100	100.2
Film Appearance	ES, T	ES, T	ES, T	E, S	IC, T	IC, sT	IC, sT	IC, sT

3.0	31	31a	32	32a	33	34	37	38
PB 2.5-1A	50.7	50.7					51.0	
2.5-2A			29.4	29.4		13.4		
2.5-5A			21.7	21.7	57.5			20.7
2.5-6A	9.5	9.5	7.8	7.8			9.5	
2.5-4A						42.6		
2.5-7A								40.5
PP 1.3-7	39.8	39.8	41.1	41.1				
1.9-1					42.5	44		
1.9-2							3.95	38.8
Ar-Octoate 1.2%		0.2		0.2				
Total	100	100.2	100	100.2	100	100	100	100
Film Appearance	ES, sT	ES, sT	ES, sT	ES, sT	IC	IC	IC	IC

3.0	41	42	44	45	46	47	48	49
PB 2.5-1A	61.7							
2.5-2A		33.9						
2.5-4A		28.6					58.5	53.4
2.5-5A						27.5		
2.5-6A			32.6	5.0	34.5	28.8		
2.5-10A			27.4	56.8	29.0			
PP 1.9-3	38.3	37.5						
1.3-1			40.0					
1.3-5				38.2				27.8
1.3-6					36.5			
1.4-1						43.7		
1.4-3							41.5	18.8
Total	100	100	100	100	100	100	100	100
Film Appearance	IC, sT	IC, sT	IC, sT	NC	IC, S	E	IC	IC, T
Potlife, min.						5	15	

Table 15 (Cont'd)

3.0	50	51	52	53	54	55
PB 2.5-1A						36.9
2.5-2A					36.8	
2.5-4A		46.5				
2.5-5A	62.6				5.4	
2.5-6A		14.6	22.0	16.4		16.9
2.5-7A				47.3	22.0	
2.5-10A			41.4			
PP 1.4-2	37.4	38.9	36.6	36.3	16.2	16.1
1.9-1					25.0	24.7
Total	100	100	100	100	100	100
Film Appearance	IC, F	IC, F	E, F	E, F	E, F	E, F
Potlife, min.	10	10	5-10	5-10	5-10	5-10
TS			333	358	606	214
EL			100	200	400	100
Tear Strength	Poor	Poor	Poor	Poor		Poor

3.0	56	57	58	59	60	61	62	63
PB 2.7-1AA	80.0	87.0	90.2	84.4	10.0	20.0	4.0	4.0
2.7-1A					70.0	60.0	76.0	76.0
PP 1.4-1			9.8					
1.4-2		13.0						
1.4-3	20.0				20.0	20.0	20.0	10.0
1.9-1				15.6				
1.9-3								27.0
Total	100	100	100	100	100	100	100	117
Film Appearance	E, F	E, F	E, F	IC, SG	E, F	E, F	E, sT	E, sT
Potlife, min.	5	5	5		15	10	30	30
TS	1200	357	200			760		
EL	720	720	100			680		

3.0	64	65	66	67	68	69	70	71
PB 2.7-1AA	9.2	7.0	9.2	8.0				
2.7-1A	72.0	66.0	72.0	76.4	82.8	84.2	85.4	32.4
2.5-2A								54.2
PP 1.9-1				15.6				
1.9-2			18.8					
1.9-3	18.8	27.0						
1.3-4					5.8	8.2	10.6	4.6
1.4-3					11.4	7.6	4.0	8.8
Total	100	100	100	100	100	100	100	100
Film Appearance	IC	ES	ES	ES	E, SG	E, SG	E, SG	ES, SG
TS	500	143	214	500	345	533	156	
EL	80	80	60	800+	520	700	400	

Table 15 (Cont'd)

3.0	72	73	74	75	76	77	78	79
PB 2.5-1A				81.6				
2.5-2A	83.0	85.6	84.6					
2.7-1A							40.4	41.4
2.7-2A						45.6		
2.7-3A					79.4	35.8	39.2	40.0
PP 1.3-4		4.8	2.8	3.4				3.4
1.4-3	17.0	9.6	12.6	15.0	20.6	18.6	20.4	15.2
Total	100	100	100	100	100	100	100	100
Film Appearance	IC	IC	IC	E, SG	E, F	E, F	E, F	E, F
TS				413	1133	366	786	889
EL				800+	800+	800+	800+	800+

3.0	80	81	82	83	84	85	86	87
PB 2.7-1A								32.8
2.7-2A		75.2		78.2				
2.7-3A	70.4		74.0				32.0	
2.7-4A					84.4	80.0	45.4	44.8
PP 1.2-1	29.6	24.8						
1.3-5			26.0	21.8		20.0	22.6	22.4
1.4-3					15.6			
Total	100	100	100	100	100	100	100	100
Film Appearance	E, F	IC, F	E, F	IC, F	IC	IC	IC	IC
TS	385		492					
EL	800+		780					

3.0	88	89	90	91	92	93	93a	93b
PB 2.7-1A			27.0					
2.7-2A		31.2						
2.7-3A	75.0	52.4	55.6	74.4				
2.7-4B					67.8	84.6	83.6	82.4
PP 1.3-1						15.4	16.4	17.6
1.8-2	25.0	16.4	17.4	25.6	32.2			
Total	100	100	100	100	100	100	100	100
Film Appearance	E, F	IC, F	IC, F	E, F	E, SG	ES, F	ES, F	ES
Potlife, min.	30	30	30	30	30			
TS	889			857	900	143	233	600
EL	800+			800+	800+	100	200	620

3.0	93c	94	95	96	97	98	99	100
PB 2.7-4B	81.2			50.0	29.2	25.4		
2.7-4C		49.4	12.6					
2.5-2A			61.4					
2.7-1A					43.0	37.2	58.6	
PCP 0300				2.4		1.2	2.0	
2.7-5A								57.4
PP 1.8-2	18.8	50.6	26.0	47.6	27.8	36.2	39.4	
1.5-3								42.6
Total	100	100	100	100	100	100	100	100
Film Appearance	ES	E	IC	E, S	E, S	E, S	E, S	IC
TS	548	893						
EL	700	520						

Table 15 (Cont'd)

3.0	101	102	103	104	105	106	107	104
PB 2.7-5A	19.4	26.2	61.2					
2.7-4A	51.8	34.8						
2.5-13A				27.0	4.0	9.4	16.6	27.0
2.5-0A					52.0	39.8	23.6	
PP 1.5-3	28.8	39.0		73.0	44.0	50.8	59.8	73.0
1.8-2			38.8					
Total	100	100	100	100	100	100	100	100
Film Appearance	IC	IC	E, G	E, F	IC	IC	E, F	E, F
TS 72 hrs			506	1800			733	882
EL 72 hrs			406	800+			60	300
TS 17 days				2280				
EL 17 days				800+				

3.0	104A	104B	104C	104Aa	104Ba	104Ca	104Da	104Ea
PB 2.5-13A	37.2	32.6	27.0	37.2	32.6	54.0		
PP 1.5-3	62.8	67.4	73.0	62.8	67.4	146.0		
DBTDL, 10% xylol (1 gm = 50 dps)			8 dps	8 dps	8 dps	6 dps	+6 dps	+12 dps
Total	100	100	100	100	100	200+	200++	200+++
Film Appearance	E, F	E, F	E, F	E, F	E, F	E, F	E, F	E, F
TS	387	562	880	600	562	882	729	824
EL	40	60	200	160	60	300	128	260

3.0	104Fa
104Ea	200
DBTDL, 10%	+24 DPS
TS	909
EL	360

3.0	108	109	110	111	112	113	116	117
PB 2.5-0A		49.4	35.8	19.6		48.0		
2.5-13A	45.0	8.6	18.6	30.6			34.4	
2.5-14A					52.0	11.0		41.2
PP 1.5-3	55.0	42.0	45.6	49.8	48.0	41.0	35.4	21.4
1.8-2							30.2	
1.8-3								37.4
Total	100	100	100	100	100	100	100	100
Film Appearance	IC, F	IC	IC	IC	IC	IC	E, F	E, F
TS						1700	1013	
EL						600	580	

3.0	118	119	120	121	122	119a	120a	121a
PB 2.5-13A		35.6	33.6			35.6	33.6	
2.5-14A	38.6			55.4	53.0			55.4
PP 1.5-3	22.4							
1.8-2								
1.8-3	39.0	64.4	66.4	44.6	47.0	64.4	66.4	44.6
DBTDL, 10%						3 dps	3 dps	3 dps
Total	100	100	100	100	100	100	100	100
Film Appearance	E, F	E, F	E, F	IC	IC	E, F	E, F	IC
TS	1283	740	869			750	840	
EL	700	700	700			700	700	

Table 15 (Cont'd)

3.0	122a	121A	121B	121C	121D	121E
PB 2.5-14A	53.0	54.4	54.4	54.4	54.4	54.4
1.8-3	47.0	44.6	44.6	44.6	44.6	44.6
DBTDL, 10%	3 dps					
DAPCO, 10% dps		10	+10	+20	+40	+40
Total	100	100	100+	100+	100+	100+
Film Appearance	IC	IC	IC	IC	IC	IC

3.0	123	124	125	123a	124a	125a
PB 2.5-13A	34.0			34.0		
2.5-14A		53.6			53.6	
2.7-5A			59.0			59.0
PP 1.9-4	66.0	46.4	41.0	66.0	46.4	41.0
DAPCO, 10%				10 dps	10 dps	10 dps
Total	100	100	100	100	100	100
Film Appearance	E, G	E, SG	E, SG	E, SG	E, SG	E, SG
TS 4 days	2460	1393	920	2338	993	805
EL 4 days	500	700	340	520	620	320
TS 7 days	2153	1013	777	2057	1014	759
EL 7 days	500	480	100	500	600	100

3.0	123A	123B	123C	123D	126	127	128	129
PB 2.5-13A	30.0	32.0	36.0	38.0	42.0		40.0	
2.5-14A						62.0		60.0
PP 1.9-4	70.0	68.0	64.0	62.0				
1.9-5					58.0	38.0	60.0	40.0
Total	100	100	100	100	100	100	100	100
Object.	Off-Ratio Mixing				Theo. NCO		Anal. NCO	
Film Appearance	ES, SG	ES, SG	ES, SG	ES, SG	ES, G	ES, G	ES, G	ES, G
TS 6 days	2371	2269	2000	1954	1851	709	1654	945
EL 6 days	560	540	620	664	652	800+	580	800+

3.0	130	131	132	133	134	135	136	137
PB 2.5-13A							14.0	
2.5-14A								26.6
2.7-7A	60.4	62.2	68.0	75.2	68.0	67.0	44.4	37.8
PP 1.9-4		37.8			20.8		27.0	23.0
1.9-5			32.0					
1.5-3	39.6					21.8		
1.8-4				24.8	11.2	11.2	14.6	12.6
Total	100	100	100	100	100	100	100	100
Film Appearance	E, SG	E, SG	E, SG	E, SG	E, SG	E, SG	E, SG	E, SG
Potlife, min.	150	120	120	15	15	15	30	30
TS 4 days	1092	1166	1442	1151	1242	923	985	746
EL 4 days	540	220	160	168	220	300	260	300

Table 15 (Cont'd)

3.0	138	139	140	141	142	143	144	145
PB 2.7-7A				10.4				
2.7-8A	76.8		53.0	64.0				
2.7-9A					57.9	67.1	58.0	
2.7-10A								65.6
2.5-15A		48.8	15.2					
PP 1.9-4	23.2	51.2	31.8	25.6				
1.9-7					42.1	32.9	42.0	34.4
Total	100	100	100	100	100	100	100	100
Film Appearance	IC, SC	IC, SG	ES, SG	ES, SG	E	ES, S	E	E
TS	1083	1185	916	1000	1100		1153	800
EL	90	720	230	80	800		800	360

3.0	146	147	148	149	150	151	152	153
PB 2.7-9A		59.8			62.6			
2.7-10A			67.4			70.8		
2.7-11A	64.8			66.6			69.2	
2.3-2B								44.2
PP 1.9-7	35.2							55.8
1.9-8		40.2	32.6	33.4				
1.1-2					37.4	30.2	30.8	
Total	100	100	100	100	100	100	100	100
Film Appearance	E	E	E	E	E	E	E	IC
TS	1114	1357	1286	1048	1214	971	1086	
EL	380	280	330	220	420	120	320	

3.0	154	155	156	157	158	159	160	161
PB 2.3-2B	46.2	49.0				64.4	64.4	
2.3-2A			45.4	48.2	48.2			
2.3-3B								56.8
PP 1.9-8	53.8		54.6					
1.9-9		51.0		51.8	51.8			
1.1-2						35.6	35.6	
1.1-3								43.2
DBTDL, 10%							5 dps	
Polypropylene Fibers					1.0			
Total	100	100	100	100	101.0	100	100	100
Film Appearance	E	E	E	E	E	ES	E	ES
Potlife, min.							10	
TS	1000	1066	889	375	706	333	579	222
EL	320	260	480	212	460	420	800+	60

3.0	162	163	164	165	166	167	168	169
PB 2.3-3B	56.8							
2.5-13A		42.0	40.0	44.0	46.0			
2.5-15A						57.2	59.2	55.2
PP 1.1-3	43.2							
1.9-5		58.0	60.0	56.0	54.0	42.8	40.8	44.8
Total	100	100	100	100	100	100	100	100
Film Appearance	E	ES	ES	ES	ES	ES, IC	ES, IC	ES, IC
TS	500	1538	1923	1714	1826	850	724	690
EL	800+	640	720	800	800	800+	800+	600

Table 15 (Cont'd)

3.0	170	171	172	173	174	175	178	179
PB 2.7-9A	59.0					42.6	49.8	
2.7-10A		66.6						58.0
2.7-11A			65.8	32.8				
2.5-13A				21.0				
2.3-1A					21.2			
PP 1.9-5	41.0	33.4	34.2	46.2				
1.9-10					78.8	57.4		
1.9-8/10 (1+)							50.2	42.0
Total	100	100	100	100	100	100	100	100
Film Appearance	ES	ES, F	ES, SG	ES, SG	Crack	Crack	ES	ES
TS	720	720	1320	1520			1034	1290
EL	800+	340	560	600			320	60

3.0	180	181	182	183	184	185	186	187
Similar to:	#123	#126	#104	#116				
PB 2.5-13A	34.0	42.0	27.0	34.4		51.4	38.4	45.0
2.7-9A					55.2			
Polypropylene Fibers	0.5	0.5	0.5	0.5				
PP 1.9-4	66.0							
1.9-5		58.0						
1.5-3			73.0	35.4				
1.8-2				30.2				
1.6-1					44.8	48.6	61.6	55.0
Total	100	100	100	100	100	100	100	100
Film Appearance	E, SG	E, SG	E, SG	E, F	E, SG	E, SG	E, SG	E, SG
TS	1285	1407	882	1161	515	494	848	705
EL	280	700	240	800+	60	80	180	120

3.0	188	189	190	191	192	193	194	195
PB 2.5-13A	46.6	53.2	54.8	51.6	47.6	34.0	38.2	43.0
PP 1.9-4	53.4					66.0	58.6	50.0
1.9-5		46.8						
1.6-1			26.0	27.8				
1.9-9			19.2	20.6				
1.7-2					52.4			
Mobay CB60							3.0	7.0
Total	100	100	100	100	100	100	100	100
Film Appearance	IC, S	ES, S	IC, S	E, S	E	E, SG	E, SG	E, SG
TS	740	433	666	937	1290	1716	1333	1067
EL	60	800+	200	300	420	640	380	160

3.0	196	197	199	200	201	202	203	204
PB 2.5-13A	49.6					46.0	43.0	50.8
'2.7-14A		57.6	61.6	63.8	68.8			
PP 1.9-4	38.4	42.4						
Mobay CB60	12.0							
1.9-5			38.4	36.2				
1.9-9					31.2			
1.7-1						54.0	57.0	
1.7-2								49.2
Total	100	100	100	100	100	100	100	100
Film Appearance	E. SG	IC, S	ES, SG	IC, SG	ES, SG	IC, SG	ES, SG	ES, SG
TS	1219	620	400	367	667	667	993	1010
EL	120	40	400	120	520	80	240	310

Table 16
Hydrolytic Stability Test

Method: 1. Cast duplicate films at approximately 15- to 20-mil thickness on release paper; cure for 7 days at 72°F, 50% relative humidity.
2. Place one film immersed in deionized water for 7 days at 140°F.
3. Remove the films and dry overnight.
4. Test for hardness, tensile strength, and elongation--untreated and treated films.
5. Express any changes as a percent deviation from the untreated film.

Test Film #:	165	123	164	126	181	193	123B	166
Film Thickness, mils:	12	13	12½	13¾	13½	12½	13	11½
Untreated								
Hardness, Shore A:	78	90	78	75	85	70	90	87
Elongation, %:	800	620	720	652	700	640	540	800
Tensile Strength, Lb:	1714	2370	1923	1851	1407	1716	2269	1826
Treated								
Hardness, Shore A:	59	58	65	62	70	50	66	55
% Retained:	76	64	83	83	82	71	73	63
Elongation:	800+	800+	800+	800+	800+	800+	800+	800+
Tensile Strength:	541	500	760	763	667	520	615	435
% Retained:*	32	21	40	41	47	30	27	24

*Since the capacity of the test equipment was exceeded, these values are not accurate; nevertheless, they are indicative of some serious problems.

Table 17
Urethane Coatings, Ether Bases

	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18
Pigmented Base:										
2.5-13B, PTM EG650, TMP	60.0	54.0	42.4	54.0	66.3	62.6	54.0	64.8	61.2	53.0
Prepolymers:										
1.9-1 PTM EG650, HMDI	40.0				22.2			21.8		
1.9-2 PTM EG1000, HMDI		46.0				26.6			26.0	
1.9-3 PTM EG2000, HMDI			57.6	36.6			36.6			36.0
1.3-8 PTM EG650, TDI				5.6	11.5	10.8	9.4	13.4	12.8	11.0
Physical Characteristics:										
Tensile Strength, Original	1050	1085	1379	933	1005	921	1176	967	914	1223
Water imm. 140°F/168 hrs	1135	1572	1600	1222	1044	941	1150	1168	1143	1600
% Retained/Increased	108	145	116	131	104	102	98	121	125	131
Elongation, Original %	413	733	753	333	433	446	766	420	466	667
Water imm. 140°F/168 hrs	420	800	1000	473	480	666	1000	480	600	766
% Increase	102	120	132	142	111	149	131	114	129	115
Shore A Hardness, Original	69	69	75	69	76	65	79	78	72	73
Water imm. 140°F/168 hrs	65	63	75	69	76	65	79	78	71	73
% Retained	94	91	100	100	100	100	100	100	99	100
Tear Strength, lb/mil	0.15	0.185	0.253	0.270	0.218	0.235	0.188	0.221	0.217	0.223

Table 18
Urethane Coatings, Ester Based

	Y1	Y2	Y3	Y4	Y5	Y6	Y7
Pigmented Bases:							
2.6-2A, PCP 0210, TMP, TDI				47.2	58.0	28.4	36.4
2.3-3A, PCP 0300	48.2	27.4	35.0			8.4	11.0
Prepolymer:							
1.5-4, PCP 0210, TDI	51.8		18.8		9.4		11.8
1.9-5 PCP 0230, HMDI		72.6	46.2				
1.9-4, PCP 0240, HMDI				52.8	32.6	63.2	40.8
Physical Characteristics:							
Tensile Strength, Original	1447	1866	1400	2085	2133	2896	2067
Water imm. 140°F/168 hrs	1100	1549	1375	2000	1925	2800	1862
% Retained	76	83	98	96	90	97	90
Elongation, Original %	200	966	433	780	453	760	426
Water imm. 140°F/168 hrs	213	1200	500	933	680	1113	646
% Increase	107	124	115	120	150	146	152
Shore A, Hardness, Original	70	60	68	86	85	86	86
Water imm. 140°F/168 hrs	60	60	68	72	72	80	70
% Retained	86	100	100	84	85	93	81
Tear Strength, lb/mil	0.225	0.138	0.211	0.514	0.437	0.480	0.291

APPENDIX: TRADE NAMES

Trade Name	Component	Company Address
Andur	Prepolymers	Anderson Development Corp. 1415 E. Michigan Street Adrian, Michigan 49221
Conap	Prepolymers	Conap 1405 Buffalo Street Olean, New York 14760
Desmodur	Prepolymers Isocyanates	Mobay Chemical Company Penn Lincoln Pkwy. West Pittsburgh, PA 15205
Formrez	Polyester Polyols Curing Agents	Witco Chemical 277 Park Avenue New York, NY 10017
Mondur	MDI, TDI	Mobay Chemical Company
Niax PCP	Caprolactone Polyesters	Union Carbide 270 Park Avenue New York, NY 10017
Novacite	Silica, flaky	Malvern Minerals Company P.O. Box 1246 Hot Springs, AR 71901
Pluracol TP440	TMP adduct, polyol	BASF, Wyandotte Corp. Wyandotte, MI 48192
Polacure 740M	Diamine curative	Polaroid Corporation 730 Main Street-1A Cambridge, MA 02139
Poly Meg	PTMEG	The Quaker Oats Co. P.O. Box 3514 Chicago, IL 60654
Quadrol	Cross linking Polyol	BASF, Wyandotte Corp.
SC-100	Aromatic Hydrocarbon Solvent	Available from most solvent suppliers
Teracol	PTMEG	E.I. DuPont deNemours & Co. Niagara Falls, NY 48192
Thixatrol ST	Thickener	N.L. Industries P.O. Box 700 Hightstown, NJ 08520
TP 440	TMP adduct (polyol)	BASF, Wyandotte Corp.

Trade Name	Component	Company Address
Vibrathane	Prepolymers	Uniroyal United States Rubber Corp. Naugatuck, CN 06770
VROH	Vinyl Resin	Union Carbide Corp.

LIST OF ABBREVIATIONS

app:	appearance
Anal:	analytical
CB 60:	Mondur CB 60
Dapco:	triethylene diamine
DBTDL:	dibutyl tindilaurate
dps:	drops
E:	excellent
EL:	elongation
EQ:	equivalent
ES:	slow cure (48 to 72 hours)
F:	flat
G:	glossy
HMDI:	hydrogenated MDI (Desmodur W)
I:	incompatible
IC:	inadequate cure
imm:	immersion
min:	minutes
MDI:	4.4′ diphenyl methane diisocyanate
N.C.:	no cure
orig:	original
PB:	pigmented polyol base
PP:	prepolymer
psi:	pounds per square inch
PTMEG:	polytetramethylene ether glycol
S:	too soft film
s:	slightly
SG:	semigloss
T:	tacky
theo:	theoretical
TDI:	toluene diisocyanate
TMP:	trimethylol propane
TS:	tensile strength (psi)
UL 28:	dibutyl tin dilaurate, fast
visc:	viscosity
Wt:	weight
Zr:	zirconium

METRIC CONVERSIONS

1 in.	≈ 25.4 mm
1 psi	≈ 6.9 kPa
1 lb	≈ 0.37 kg
$\frac{{}^\circ F - 32}{1.8}$	≈ °C

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